Space Weather Technical Forecast

Issued on Tuesday, 23 May 2023 at 13:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of further R1/R2 radio blackouts likely. Chance of G1 Minor/G2 Moderate storm intervals Days 1-2. Active fluence likely from late Day 2.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with an isolated M-Class flare of M1.9 at 22/1337UTC from AR3312. This is a small region in the southeast disc that has subsequently decayed further. There are currently six other regions on the visible disc. AR3311, in the northeast quadrant, remains the most complex region and contains a marginal delta spot, although has shown signs of slight decay. AR3310 is the largest region on the disc and is dominated by a large umbra with much smaller surrounding spots that have shown some evolution and development in the last 24 hours. AR3308 has almost entirely rotated across the western limb and is only just visible. One unnumbered region in the southeast has recently developed as a Dro/Beta. The remaining regions are all relatively small and simple.

A weak CME was produced by the M1.9 flare off the southeast disc. Although this has been analysed as a miss, it is likely to pass close to the Earth on 26-27 May with some uncertainty in arrival time or effects due to limited imagery available for analysis. No other Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed at L1 have been elevated at 500-600 km/s, perhaps due to a connection to the fast wind of CH06/-, although the onset of these elevated winds appeared to be too early for originating from this feature. Density was largely below average, with a period of (or just above) average 22/1529-23/0017UTC. The total IMF strength Bt, was Weak to Moderate, ranging from 3 to 11nT. The north-south component Bz was variable, but predominately negative, ranging from -9nT to +8nT. Since around 23/0330UTC Bz has been mostly positive. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was mainly Unsettled to Active (Kp3-4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout. High energy electron flux (greater than 2MeV), as measured at GOES16 was initially at background levels, with the diurnal peak crossing the threshold to High on a number of occasions 22/1455-1625UTC, reaching a peak of 1270 pfu at 22/1615 UTC before falling back to background levels. Electron flux levels are currently close to, but just below the High threshold. The 24-hour integrated fluence has been below Active. The 22/0000UTC observed fluence was, 2.1e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with a chance of further M-class flares. The main risk region remains AR3311 in the northeast quadrant despite showing signs of stabilisation.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs, although a weak CME passing nearby may give a glancing influence late on Day 4 (26 May). Current elevated or strong solar winds are expected to persist Days 1-3 (23-25 May), waning Day 4 as influence from

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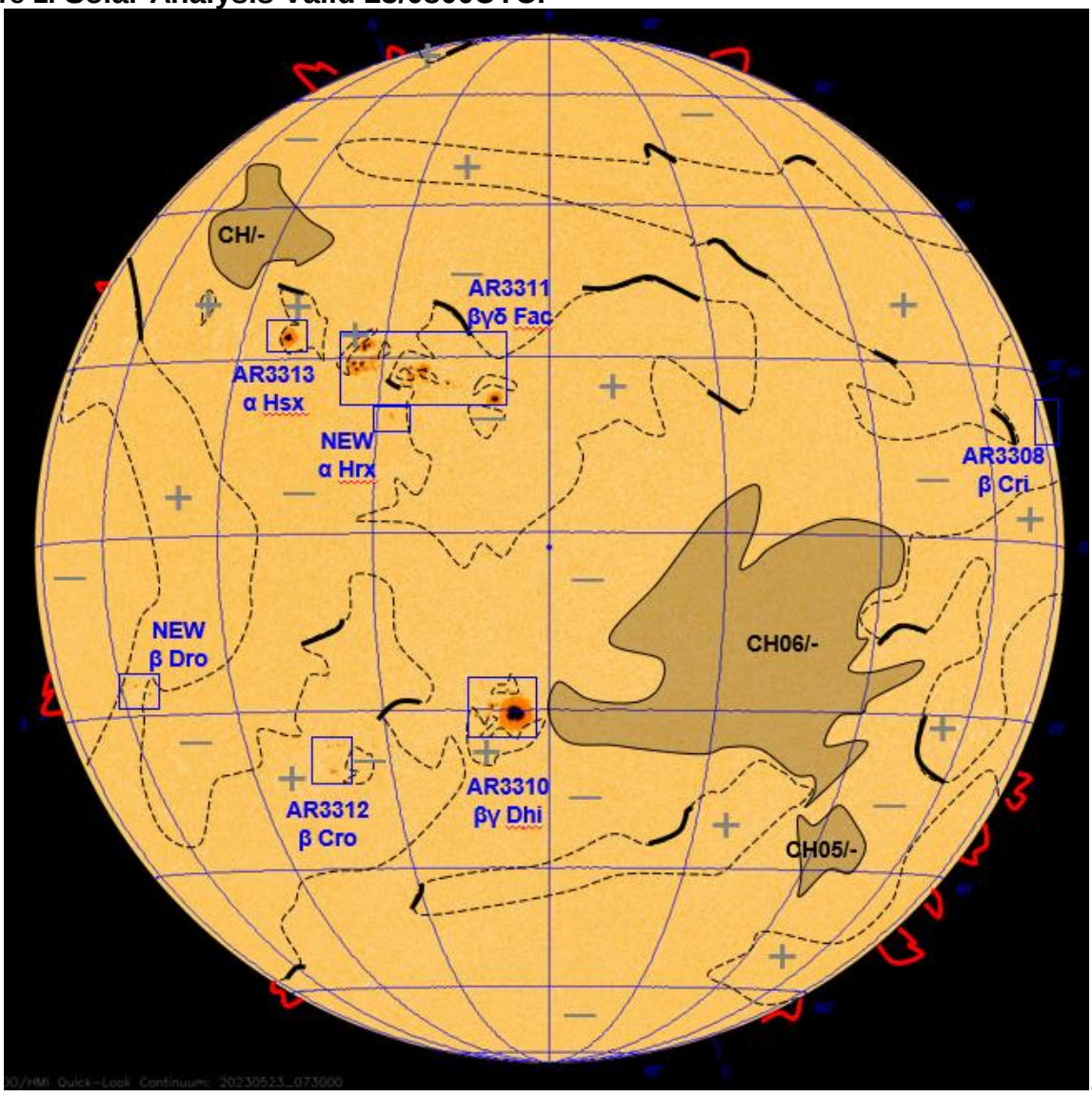
CH06/- wanes. The current source of these winds is uncertain, but likely CH06/-, but also with a potential to still connect to the HSS later Day 1 (23 May). Unsettled to Active (Kp3-4) geomagnetic activity expected with a chance of G1/Minor Storm intervals (Kp5), mainly Day 1 but perhaps Day 2 (24 May). Activity easing to mainly Quiet with Unsettled intervals (Kp0-3), and a chance of isolated Active (Kp4) spells by Day 4.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be at background, but carries a chance of rising in response to any large flares that occur, with a slight chance of reaching the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) will likely rise, erratically at first, but more persistently Day 2 (24 May) onward with diurnal periods of High flux levels. The associated electron fluence levels are likely to reach and cross the Active threshold by the end of Day 2, and more likely Days 3-4 (25-26 May).

Figure 1. Solar Analysis Valid 23/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Currently there are no Earth-directed CMEs, although a weak CME from the M1.9 flare of AR3312 at 22/1337 UTC is expected to pass close, to the south and behind Earth. Enlil ensemble members indicate a glancing blow is possible later Day 4 (26 May) or just beyond the forecast period, however, there is low confidence in this due to limited imagery available for analysis.

Solar winds are currently at Elevated levels around 500-550km/s. The most likely source of this enhancement is a high speed stream (HSS) from CH06/-, a large feature in the southwest disc. However, the onset of these winds were considered too early and may indicate enhancement from the much smaller CH05/-, which previously displayed a more westerly leading edge. This brings significant uncertainty to the source of the elevated winds, with a connection to CH06/- still possibly yet to occur on Day 1 (23 May). A further coronal hole in the northwest quadrant is not expected to have any influence on the forecast during this period.

Despite this uncertainty, elevated to strong solar winds are expected Days 1-3 (23-25 May) with speeds of around 550-650km/s. in the absence of further CME enhancement, winds are expected to gradually ease to slightly elevated levels through Day 4 (26 May) as influence from the HSS wanes. This will bring mainly Unsettled to Active geomagnetic activity with a chance of G1/Minor Storms, mainly Day 1 but perhaps Day 2 (24 May). Activity easing to mainly Quiet with Unsettled intervals, and a chance of isolated Active spells by Day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	20	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

No Earth-directed CMEs are currently expected during the period. See ‘Geomagnetic Storms’ section for more details.

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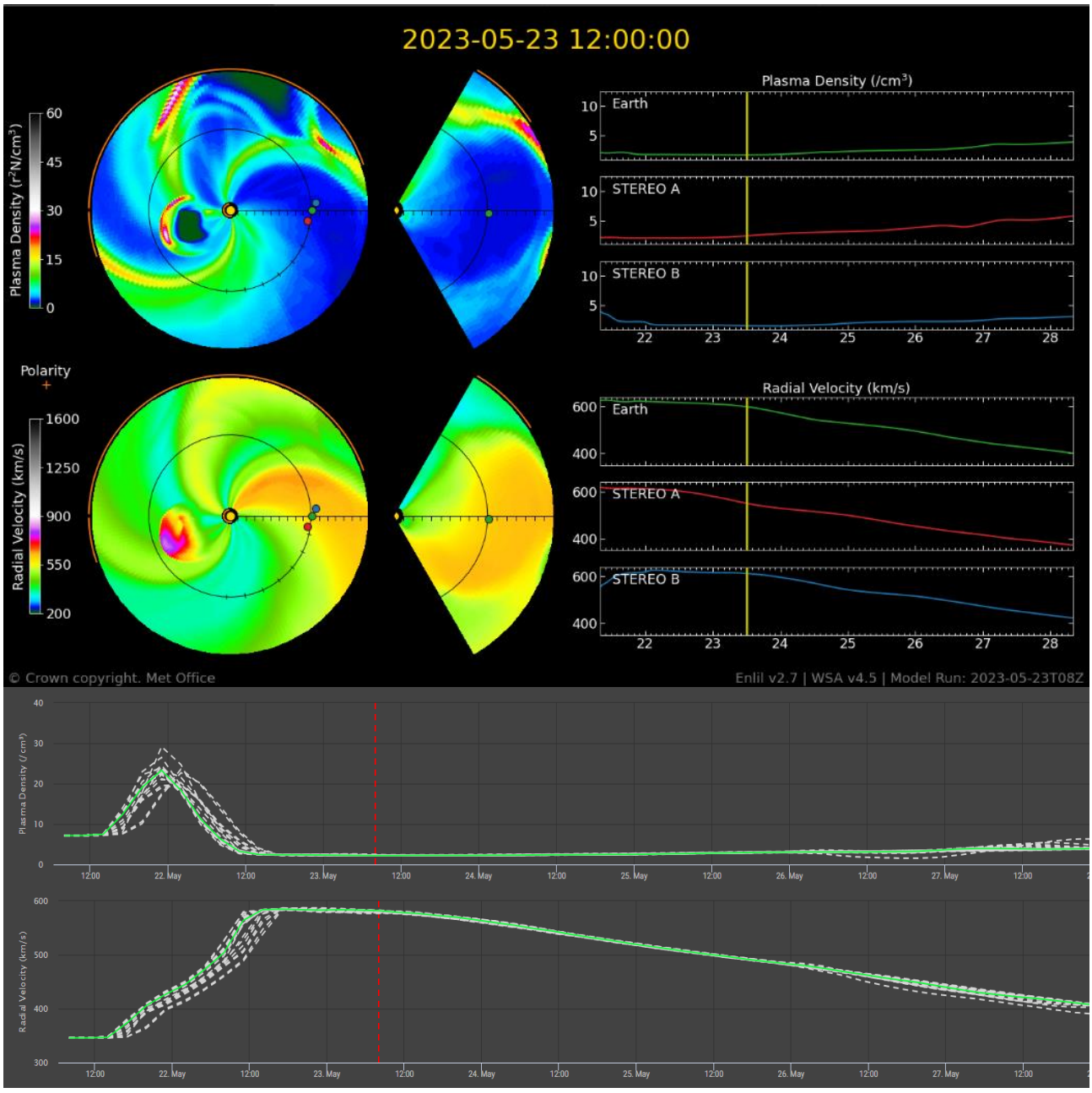
Figure 2: MOSWOC Enlil and Ensemble showing slight chance of a glancing blow 26-27 May. Enhanced solar wind speeds are considered to drop off too quickly on Enlil



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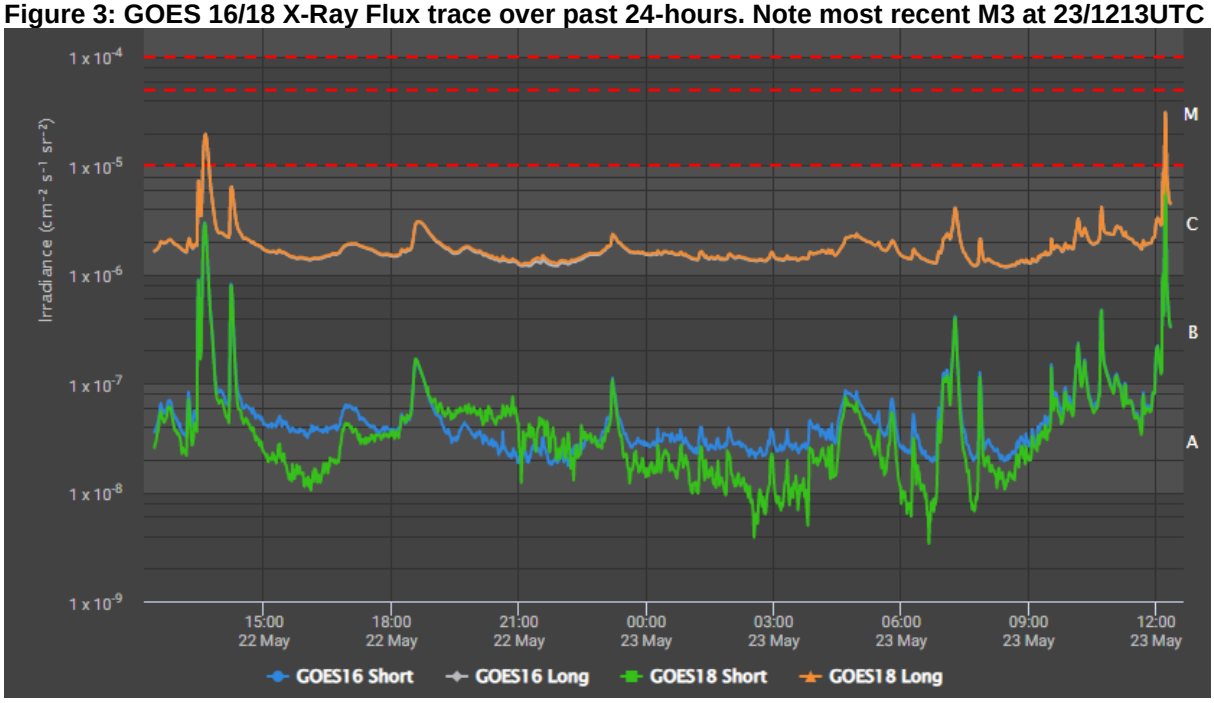
Radio Blackouts - X-Ray Flares:
There are currently 5 numbered and 2 unnumbered regions on the visible disc. AR3311 in the east hemisphere remains the most complex region on the disc, but with signs of slow simplification. The delta spot amongst its intermediate spots is marginal. Along with spreading and reduction of visible spots, this suggests a decreasing risk of significant flares and a stabilising trend. Flux emergence has been observed around large spot AR3310, with the development of a couple of reverse polarity spots, along with small intermediate spots. Small and simple AR3312, which was the source of the largest flare in the last 24 hours, has since decayed.

No significant changes have been observed in the other numbered regions which remain largely simple and stable. The new region to the southeast of AR3311 remains small and simple. A further region has developed in the southeast of the disc and is currently classified Dro, as viewing angle improves so too will confidence in classification.

AR3308 is expected to soon completely rotate beyond the western limb. A new region is set to emerge across the northeastern limb by Day 2 (24 May). The overall balance of flare risk remains unchanged as a result of the uncertainty in the complexity of the new region.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	45	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16/18 X-Ray Flux trace over past 24-hours. Note most recent M3 at 23/1213UTC



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at background levels throughout and is expected to remain as such throughout the period.
There is the potential for some enhancement with the main risk from any larger flares from the complex region AR3311 as it rotates westward into the period, but also from regions that have recently rotated beyond the western horizon. As such a slight risk is maintained throughout.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed at GOES-16 was initially at Background levels, before diurnal variation crossed the threshold at peak to High on a number of occasions 22/1455-1625UTC. This is likely a consequence of the increase in electrons from the recent solar wind enhancements. The elevated solar winds likely also suppressed the observed flux at GEO due to the compression of the Van Allen belt to below this level, with a gradual easing of solar wind pressure expected towards the end of the period, counts are expected to rise at GEO, bringing more persistent Moderate, and increasingly long periods of High flux from Day 2 (24 May) onwards.

The associated 24 hour electron fluence is likely to remain below the Active threshold until Day 2, when there is an increasing likelihood of fluence rising above this level. This rising trend is supported by REFM, which is giving reasonable guidance up to T+24. Beyond this, REFM is currently below the expected observed fluence, with Active fluence likely.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	60	70	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 5: Diurnal variation in Electron Flux values over past 24-hours

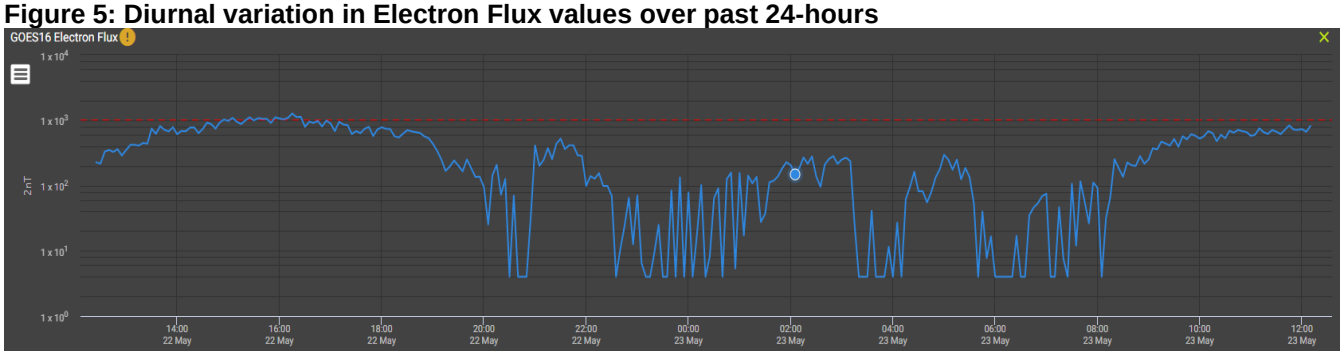
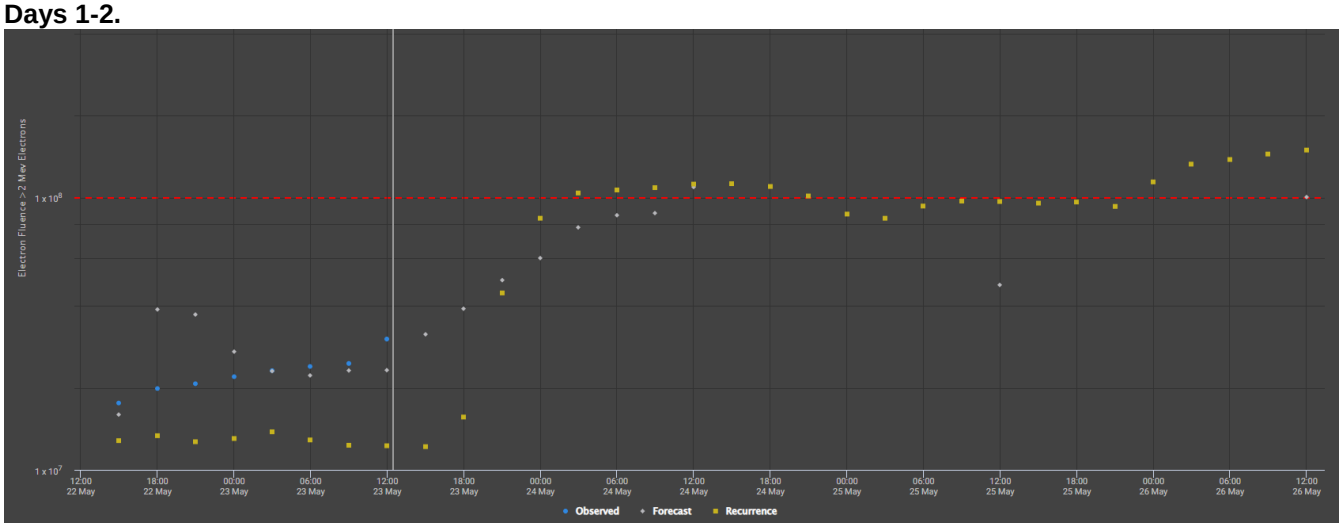


Figure 6: MOSWOC REFM showing forecast Electron Fluence. Considered reasonable guidance for Days 1-2.



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